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5

Empathy, Imitation, and the Social Brain

Jean Decety and Andrew N. Meltzoff

5.1 Introduction

Imitation and empathy have long been studied by developmental and social psychologists. These topics now are hotbeds of interdisciplinary activity and are being influenced by discoveries in cognitive neuroscience, which has begun to delineate the neural circuits that underpin these phenomena. The goal of this chapter is to bring together findings from developmental science and cognitive neuroscience on imitation and empathy.

We place imitation within this larger framework, and it is also proposed to be grounded in shared motor representations between self and other (Meltzoff & Decety (2003)) as well as regulated by executive functions (Decety (2006a)). Moreover, imitation has been theorized to scaffold the child's developing sense of agency, self, and self–other differentiation, which are also phenomenal characteristics involved in empathy. Thus, imitation and empathy are closely linked, but they are not underpinned by the identical neurological process. They are instead partially distinct, though inter-related. Studying the development and neural bases of these two abilities will enhance our understanding of both.

5.2 Infant Imitation and Foundations of Social Understanding and Empathy

Human infants are the most imitative creatures in the world. Although scattered imitation has been documented in other species, *Homo sapiens* imitate a larger range of behaviors than any other species, and they do so spontaneously, without any special training. Within the developmental literature, a good deal has been discovered about the origins and early development of the human capacity to imitate. A selective review of this work is provided below with the goal of assembling research that is relevant to the modern discoveries about the neural mechanisms underpinning imitation and empathy.

5.2.1 Innate imitation

Meltzoff and Moore (1977) discovered that 12- to 21-day-old infants imitated tongue protrusion, mouth opening, lip protrusion, and hand movements. Infants responded differentially to two types of lip movements (mouth opening vs lip protrusion) and two types of protrusion actions (lip protrusion vs tongue protrusion). Other research demonstrated that infants differentiated two different types of tongue movements from one another, namely tongue protrusion that is thrust off-midline (slanted towards the corner of the mouth) versus the more typical tongue protrusion-withdrawal that occurs at midline (Meltzoff & Moore (1994)). Thus the neonatal imitative response is quite specific; it is not a global or a general arousal reaction.

There is also evidence that this early matching cannot be reduced to automatic resonance and is more interesting than may first appear. In one study a pacifier was put in infants' mouths as they watched the display so that they could only observe the adult demonstration but not duplicate the gestures. After the infant observed the display, the adult assumed a passive face pose and only then removed the pacifier. After the pacifier was removed, the infants imitated the earlier displays (Meltzoff & Moore (1977)). Other research documents imitation after the memory delay of 24-hours. Six-week-old infants came in on one day, observed the gestures, and went home. They then returned the next day and observed the person who showed the gestures the day before now sitting motionless with a passive face. Infants successfully imitated based on their memory of the person's now absent motor acts (Meltzoff & Moore (1994)). If the adult had shown mouth opening the day before, the infants initiated that gesture; if the adult had shown tongue protrusion, infants responded with that gesture.

Research also reveals that the response is not rigidly fixed in the form of a 'fixed-action pattern.' Infants correct their imitative attempts so that they more and more closely converge on the model demonstrated. For example, if the adult shows a novel gesture such as tongue-protrusion-to-the-side-of-the-mouth, infants will begin with ordinary tongue protrusions. They use the proprioceptive feedback from their own actions as the basis for guiding their response to the target (Meltzoff & Moore (1997)).

The participants in the previous studies were 2- to 6-weeks old. At first glance this seems young enough to justify philosophical claims about an 'innate behavior.' But perhaps neonates had been conditioned to imitate during the first weeks of life. Perhaps imitation is dependent upon prior mother–infant interaction. To resolve the point, Meltzoff and Moore (1983) tested forty newborns in a hospital setting. The average age of the sample was 32 hours old. The youngest infant was only 42 minutes old. The results showed that the newborns differentially imitated both of the gestures shown to them, mouth opening and tongue protrusion. Nativist claims are, of course, commonplace in the philosophical literature, but few tests have been conducted on newborns. You can't get much younger than 42 minutes old. *Homo sapiens* have an innate capacity to imitate. The question now becomes: What psychological and neurological mechanisms underpin this capacity?

5.2.2 The AIM mechanism for early imitation

Meltzoff and Moore proposed that facial imitation is based on 'active intermodal mapping'—the AIM account (Figure 5.1). On this view infants can, at some primitive level, recognize an equivalence between the acts they see others do and the acts they do themselves. This is not a complex mechanism that requires cognitive machinations by the infant. Rather, there appears to be a very primitive and foundational 'body scheme' that allows the infant to unify the seen acts of others and their own felt acts into one common framework. The infant's own facial gestures are invisible to them, but they are monitored by proprioception. Conversely, the adult's acts are not felt by proprioception, but they can be seen. Infants can link observation and execution through what AIM terms a common 'supramodal' coding of human acts. This is why they can correct their imitative movements. And it is why they can imitate from memory: Infants store a representation of the adult's act and it is the target against which they compare their own acts. A detailed description of the metric infants use for establishing the common 'supramodal' framework between self and other is provided elsewhere (Meltzoff & Moore (1997)). The theoretical connections between infant motor imitation and human empathic reactions warrants close attention (see subsequent sections); the discovery of early motor imitation suggests a psychological and philosophical foundation for empathy prior to human language and complex adult thought.

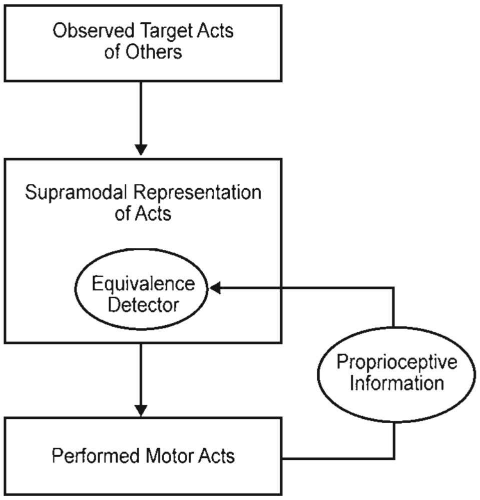

Figure 5.1 The AIM model of imitation. A supramodal representation unites the perception and production of acts within a common act space. The neural underpinnings of this supramodal representation are currently being explored (see subsequent sections of this chapter).

Source: Meltzoff & Moore (1997), with permission.

Meltzoff and Moore's hypothesis of a supramodal framework for actions emerged from developmental studies and fits well with proposals from cognitive science about action coding (the 'common coding' thesis of Prinz (1997, 2002)) and neuroscience discoveries about the mirror neuron system and shared neural circuits (see subsequent discussion in this chapter). The unique contribution from developmental science is that newborn imitation demonstrates that self–other connectedness is functional *at birth* in the human case. Imitation is a marker of innate intersubjectivity in action. At the same time, it must be underscored that newborn humans are different from both monkeys (who exhibit mirror neurons but little imitation), and from human adults. More analytic work is needed to determine whether the current convergences between the AIM hypothesis (on the psychological level), mirror neurons, and shared representations (on the neuroscience level), and other aspects of social understanding (at the philosophical level) are merely surface similarities or more substantive.

5.2.3 The 'Like Me' developmental framework

According to classical developmental theory (Piaget (1954, 1962)), newborn humans are 'solipsistic' and cannot apprehend any equivalences between self and other. The puzzle has always been to describe a developmental theory that could get an infant from such solipsistic beginnings to the empathetic, mindreading adults we see around us.

Instead of Piaget's infant solipsism theory, and based on the modern empirical work in developmental science, Meltzoff (2007a, 2007b) proposed a 'Like-Me' developmental framework for describing the infant's initial state and the early phases of intersubjectivity. The 'Like-Me' developmental framework holds that early imitation and the mechanisms that underlie it allow infants to see the behaviors of others as commensurate with their own and that this action coding in turn provides the groundwork for other developments in empathy and the grasp of other minds. The 'Like-Me' developmental framework has three steps which occur during the infancy period, prior to language (Figure 5.2). It describes the infant's innate state (step 1) and also provides an engine for change in interpersonal understanding (steps 2 and 3). The older child and adult are not locked into the same understanding of others as the newborn.

Step 1: Action representation. The first step in Meltzoff's developmental-psychological model is based on the innate equipment infants bring to interpersonal encounters. Newborn imitation provides evidence that the perception and production of acts are tightly bound in human beings. Meltzoff & Moore (1997) proposed that imitation is mediated by a 'supramodal' action representation that enables commensurate coding of acts seen and acts done (for neuroscience underpinnings, see subsequent sections of this chapter). This does not mean that the infant yet has a full blown sense of self, which surely undergoes developmental change. Rather, it suggests that there is an innate capacity to connect actions produced by the self and observed in others. This fundamental interpersonal connection is not a learned 'association,' nor acquired by looking

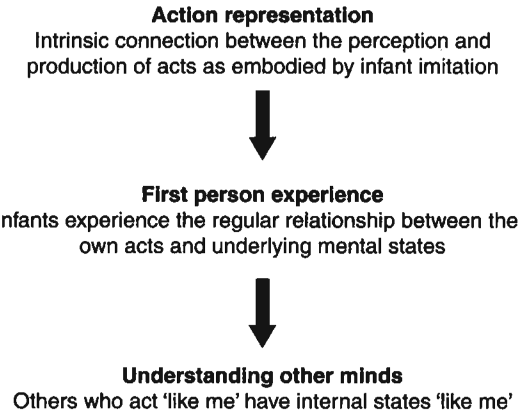

Figure 5.2 'Like Me' developmental framework: First steps for getting empathy and perspective-taking off the ground.
Source: Meltzoff (2007b), with permission.

in the mirror. Based on the supramodal representation of action, the acts of self and other can be recognized to be equivalent from birth onwards, and this rich innate groundwork supports further development of the intersubjectivity based on infants' own particular action experience and interaction with other social agents (see Meltzoff (2007a) and below).

Step 2: First-person experience. The second step provides an engine for developmental change. Through everyday experience infants map the relation between their own bodily states and mental experiences. For example, there is an intimate relation between striving to achieve a goal and a concomitant facial expression and effortful bodily acts. Infants experience their own unfulfilled desires and the simultaneous facial/postural behavior that accompany such states. These first-person experiences contribute to a detailed bidirectional map linking internal states and behavior. It is crucial for philosophical theories to realize that all of this can happen prior to language.

Step 3: Understanding other intentional agents 'like me'. The third step involves attribution (Meltzoff & Brooks (2008)). When infants see others acting similarly to how they have acted in the past, they ascribe the internal state that regularly goes with that behavior. There is new empirical evidence that this occurs pre-verbally, without complex reasoning (Meltzoff & Brooks (2008)).Infants' first-person experiences could not be used in this way if they did not perceive an equivalence between their own acts and those of others (step 1). Nor would it get very far if there was no systematic link between their own internal states and bodily acts (step 2). Humans, including pre-verbal infants, imbue the acts of others with felt meaning not solely (or at first) through a formal process of step-by-step reasoning, but because the other is processed as 'like me,' as manifest by early facial imitation. This is underwritten by the way infants represent action—the supramodal action code—and self experience.

Through pre-verbal interaction with other intentional agents who are viewed as 'like me,' infants develop a richer grasp of intersubjectivity and empathy for others (Meltzoff & Brooks (2008)).

Of course, philosophers have long discussed whether an analogy between self and other plays a role in our treatment of others as intentional agents. Empathy, perspective-taking, and several varieties of putting yourself in someone else's shoes emotionally seem to depend on this. A problem for philosophers has traditionally been that this self–other connection was thought to be a late achievement and perhaps dependent on language, and therefore thought not to play a formative role during the pre-verbal period of human development. Few philosophers, prior to the discovery of newborn imitation, took infant behavior as input into theories of human empathy. The modern findings from developmental science show that infants already register the equivalence between acts of self and other. It is not a derived, complex, or cognitively advanced analysis of the world. It is an innate relation to others, and must be taken seriously in our psychological and philosophical accounts of the origins of empathy.

Newborn imitation indicates that, at some level of processing no matter how primitive, infants can map actions of other people onto actions of their own body. Because human acts are seen in others and performed by the self, the infant can grasp that interpersonal connection: You can act 'like me' and I can act 'like you'—Meltzoff's (2007a) 'Like Me' bridge. This self–other equivalence provides a privileged access to people not afforded by things. It provides a groundwork for sharing and communication that goes beyond the perceived movements per se. As we will see in subsequent sections of this chapter, this basic self–other connection, empirically demonstrated in pre-verbal humans, has implications for how we conceptualize the roots of human empathy.

5.2.4 Top-down control and regulation of imitation

Imitation is also connected to empathy in deeper ways as well. Adults do not blindly and automatically imitate everything they see. If they did, it would cause chaos in normal social interaction. Instead, adults regulate their behavior and choose when to copy others. Developmental scientists have recently investigated some of the factors that regulate imitation by children. The results are intriguing, because they reveal the origins of the inhibitory control of behavior that will become important in more mature imitation and empathy for others in adults (see discussion below). In this section we review recent work on the regulation of imitation based on: (a) the perceived goals of the model, (b) the emotional consequences of the act, and (c) the prior motor experience of the child.

Goals and Intentions. In the mature adult social cognition, other people not only motorically act 'like me,' they also are understood to have other mental states, including beliefs, emotions, and intentions. When do pre-verbal infants begin to ascribe intentionality to human movement patterns? The behavioral re-enactment procedure was designed to provide a non-verbal technique for exploring intention reading in pre-verbal creatures (Meltzoff (1995)). The procedure capitalizes on children's natural tendency to re-enact or imitate, but uses it in a more abstract way to investigate whether infants can read below the literal surface behavior to the goals or intentions of the actor.

The experimental procedure involves showing infants an unsuccessful act. For example, the adult accidentally under- or overshoots his target, or he tries to pull apart a dumb-bell-shaped toy but his hand slips off the ends and he is unsuccessful. Thus the goal-state is not achieved. To an adult, it is easy to read the actor's intentions although he never fulfills them. The experimental question is whether children read through the literal body movements to the underlying goal or intention of the act. The measure of how they interpreted the event is what they choose to re-enact, in particular whether they choose to ignore what the adult literally did and instead produce the intended act despite the fact that it was never present to the senses. In a sense, the correct answer is to not copy the literal movement, but the intended act that remains unfulfilled and invisible.

Meltzoff (1995) showed 18-month-old infants an unsuccessful act, a failed effort. The study compared infants' tendency to perform the target act in several situations: (a) after they saw the full-target act demonstrated, (b) after they saw the unsuccessful attempt to perform the act, and (c) after it was neither shown nor attempted. The results showed that 18-month-olds can infer the unseen goals implied by unsuccessful attempts. Infants who saw the unsuccessful attempt and infants who saw the full-target act both produced target acts at a significantly higher rate than controls. Evidently, toddlers can understand our goals even if we fail to fulfill them.

In the adult framework, people act intentionally but inanimate things do not. To begin to examine this question of the ascription of intentionality, Meltzoff (1995) also tested how 18-month-olds responded to a mechanical device that mimicked the same movements as the actor in the unsuccessful-attempt condition. An inanimate device was constructed that had poles for arms and mechanical pincers for hands. It did not look human but it could move very similarly to a human. For the test, the pincers 'grasped' the dumb-bell at the two ends just as the human hands did. One mechanical arm was then moved outwards, just as in the human case, and its pincer slipped off the end of the dumb-bell just as the human hand did. The movement patterns of machine and man were closely matched from a purely spatio-temporal description of movements in space.

The experimental results showed that infants did not attribute a goal or intention to the movements of the inanimate device. Although they were not frightened by the device and looked at it as long as at the human display, they did not see the sequence of actions as implying a goal. Infants were no more (or less) likely to pull apart the toy after seeing the unsuccessful attempt of the inanimate device than in baseline conditions when they saw nothing. Another study pursued this point. In this study the inanimate device succeeded. The inanimate device held the dumb-bell from the two ends and successfully pulled it apart. When infants were given the dumb-bell, they too pulled it apart.

It thus appears that infants can pick up certain information from the inanimate device (they pull it apart after seeing the device do so), but they cannot pick up other information (concerning unsuccessful attempts).

By 18 months of age children have already adopted a fundamental aspect of a mature common-sense psychology—persons are understood within a framework involving goals and intentions. Just as importantly, the work shows that children did not slavishly imitate the unsuccessful motion by letting their fingers slip from the object, but instead completed the intended goal. Even though they had never seen the completed act, the children inferred the goal of the act from his try-and-try again behavior. This and other related work strongly suggests that infants can interpret what the adult is trying to do. They re-enact the goal of the act, not what was literally done.

Emotions and Attention. Recent work shows that 18-month-old infants regulate their imitation based on another person's *emotional reaction* to the act (Repacholi & Meltzoff (2007); Repacholi, Meltzoff, & Olsen (2008)). An adult model performed a series of novel acts on objects and an adult bystander either became angry at these 'forbidden acts' or remained pleasantly interested in what the model was doing. After this emotional reaction, the emoter adopted a neutral face. The infant watched this interaction between the two adults, and the question was whether infants regulated their subsequent imitation based on the emoter's reaction. A second factor that was manipulated was whether the emoter was *looking at* the toddler when the infant was given a chance to imitate. The experimental manipulations included: (a) the emoter left the room, (b) the emoter was present but had her back turned so she could not watch the infant's response, (c) the emoter was facing the infant but had her eyes closed, and (d) the emoter watched the infant's response.

The empirical results showed that if the adult had not exhibited anger at the action, the infants imitated at high levels regardless of whether or not the emoter could see them. But if the emoter had previously become angry at seeing the act, then the infants were significantly less likely to imitate the act but only when the previously angry emoter was watching them. The infants' imitated if the previously angry adult left the room, or had her back turned, or had her eyes closed, and presumably could not monitor the infant's behavior.

These effects cannot be explained simply by emotional contagion. Infants are subject to contagion, but the interesting point is that even during the pre-verbal period, their intersubjectivity is based on more than this. The infants in this study had the chance to 'catch' the adult's emotion equally well in all groups. Instead the toddlers' were regulating their imitation based on the conjunction of two factors: (a) whether the bystander had a negative reaction to the act *and* (b) whether the bystander was watching what the infant did. Evidently, infants regulate their imitative response based on the emotional reactions that others have to the target act and whether the emoter can monitor their imitative reactions or not. Infants realize that they can be a target of other people's perception and will not imitate an action when the emoter is watching them produce those actions. Imitation is thus not automatic and inflexible by

18 months of age. Instead, infants can self-regulate and actively choose when to imitate—the emotions and attention of others play a role.

Prior Motor Experience and Perceived Efficacy of the Model. Other recent studies have taken the self-regulation aspect of imitation a step further and show that young children are highly selective in choosing who, what, and when to imitate. In one series of studies 36-month-old children were tested to see if they were more open to imitating another person's technique if the child had a prior motor experience himself showing that the task was difficult to solve (Williamson, Meltzoff, & Markman (2008)). Children were randomly assigned to two independent groups. One group had an "easy experience" and the other a "difficult experience" in achieving an outcome, such as opening a drawer to retrieve an object. For the "easy" group the drawer easily slid open when the child tried to do so; for the "difficult" group the drawer was surreptitiously held shut by a resistance device. Then the model demonstrated a distinctive technique for opening the drawer. The same distinctive technique was demonstrated to both groups. The results showed that children were significantly more likely to imitate after having difficulty with the task. In a related study, children watched a model who demonstrated a particular technique, but for half the children the technique led to success and the other it led to the model's failure. The results showed that children took the model's causal efficacy into account and selectively chose to imitate the actions only when they led to success and not failure.

Across these studies, it is theoretically significant that preschoolers are actively balancing two streams of information—their own actions and the actions that they see another person perform. Future research will focus on the commensurability of these two streams and how children can learn and combine information from self and other. Taken together, this research suggests that infants and young children are not automatic, rigid imitators, but rather choose who, what, and when to imitate.

So far we have shown both the close coupling between perception and action that underlies imitation and also the fact that young children can regulate their imitation and behavior. As we will see, these two factors also play an important role in neuroscientific views of empathy (for further discussion relating imitation, the problem of other minds, and social learning, see Meltzoff, Kuhl, Movellan, & Sejnowski (2009)).

5.3 Linking to Empathy: A Neuroscience View

Like imitation, empathy is a complex term with various definitions in the literature. Broadly construed, empathy has been defined as an affective response stemming from the understanding of another's emotional state or condition similar to what the other person is feeling or would be expected to feel in the given situation, without confusion between self and other (Decety & Meyer (2008); Eisenberg, Shea, Carlo, & Knight (1991)). In line with this conception, empathy is an interaction between two individuals, with one experiencing and sharing the feeling of the other.

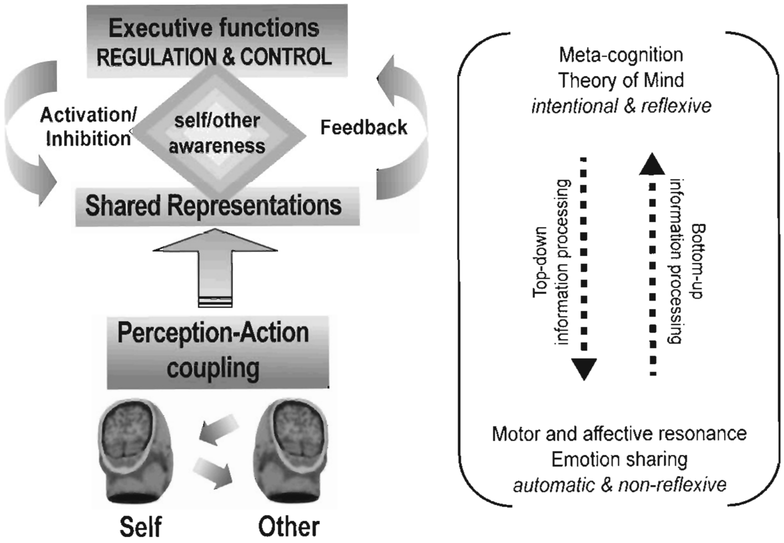

Figure 5.3 Schematic representation of the mechanisms underpinning the experience of empathy. Two dimensions interact: (1) bottom-up (i.e. matching between perception and action), and (2) top-down (i.e. regulation and control) information processing. The bottom-up processing level, which is rapidly activated (unless inhibited) by perceptual input, accounts for emotion sharing and the implicit recognition that others are like us. This aspect functions soon after birth (see also Figure 5.2). The top-down level, which overlaps with the notion of executive control is implemented in the prefrontal cortex, and develops gradually during early childhood. Executive control regulates both cognition and emotion, notably through selective attention and self-regulation. This meta-level is continuously updated by bottom-up information, and in return controls the lower level by providing top-down input. Thus, top-down regulation, through executive functions, modulates low levels and adds flexibility, allowing the individual to be less dependent on external cues. The meta-cognitive feedback plays a crucial role in taking into account one's own mental states in order to react (or not) to the affective states of others. Self–other awareness is an important aspect of this model. The computational mechanism of self–other distinction is crucial for the higher-level cognitive processing involved in social cognition such as empathy and theory of mind. Both empathy and theory of mind involves an ability to simultaneously distinguish between different possible perspectives on the same situation.

Source: Decety (2006b); Decety & Lamm (2006); Decety & Meyer (2008); with permission.

In the following sections we discuss the affective and cognitive components of empathy, reviewing first the automatic proclivity to share emotions with others, and the cognitive process of perspective-taking and executive control, which allow individuals to be aware of their intentions and feelings and keep separate self and other perspectives. We examine empathy within an overarching conceptual framework. This framework considers that empathy involves parallel and distributed processing in a number of dissociable computational mechanisms (see Figure 5.3). Shared neural circuits, self-awareness, mental flexibility, and emotion regulation constitute the basic macro-components of empathy, which are mediated by specific neural systems, including aspects of the prefrontal cortex, the anterior insula, and fronto-parietal networks. This model assumes that dysfunction in any of these macro-components may lead to an alteration of empathic behavior, and produce selective social disorders depending on which aspect is disrupted.

It should be noted that the experience of empathy does not necessarily entail imitation. Imitation can be viewed as a stepping stone in the *development* of empathy and not a sole cause or explanation. It is interesting that full-blown empathic experience does not mature until 2–4 years of age, a time in which executive functions develop rapidly. However, the initial building block of empathy is emotion sharing, which can be observed earlier in infancy. Moreover, emotion sharing itself is closely related to the perceptual-action mapping manifest in early motor imitation. More complex imitation, which involves intentional and conscious behavior matching as well as the regulation of imitation based on top-down inhibitory control, is theoretically tied to developing a sense of agency. Agency plays a role in empathy, as it facilitates knowing whose actions and emotions belongs to whom and keeps individuals from over-identifying with the observed target which would otherwise lead to empathic distress. Thus imitation and empathy are intimately intertwined. If emotion sharing fails to take place, disorders are implicated, specifically individuals with autism spectrum disorder (ASD) and psychopaths (which clearly are very different populations with different etiologies).

5.4 Emotion Sharing

5.4.1 *The automaticity of emotion sharing*

A basic building block of empathy is emotion sharing, and this process is facilitated by motor mimicry, i.e. a form of unconscious mirroring of the other person's behavior. Bodily expressions help humans and other animals communicate various types of information to members of their species.

Emotional expression not only informs an individual of another's subjective (and physiological) experience, but also serves as a sort of social glue maintaining emotional reciprocity among dyads and groups. Emotional contagion, defined as the tendency to rapidly mimic and synchronize facial expressions, vocalizations, postures, and movements with those of another person and, consequently converge emotionally with the other (Hatfield (2009); Hatfield, Cacioppo, & Rapson (1993)) is a social phenomenon of shared emotional expression that often occurs at a basic level outside of conscious awareness.

5.4.2 *Infant emotion sharing*

In classic developmental work, Meltzoff and Moore (1977, 1997) showed that infants less than one hour old mimic human actions. The findings suggest that infants enter the world with an innate sociability, grounded in action-perception coupling. Such imitative behaviors led Trevarthen (1979) to propose that infants are endowed with an innate 'primary subjectivity.' That is, infants have access to others' emotional states via perceiving the other person's actions and facial gestures. Indeed subsequent research showed that young infants can match emotion expressions of others (e.g. Field, Woodson, Greenberg, & Cohen (1982)) and engage with other people and with the actions and feelings expressed through other people's bodies (e.g. Hobson (2002)). These imitative and reciprocal bodily exchanges are critical for many facets of social functioning. For example, they facilitate attachment by regulating one's own emotions and providing information about the other's emotional state. These recriprocal gestural interactions also constitute a primary source of interpersonal engagement with others, what has been termed primary intersubjectivity (e.g. Gallagher & Meltzoff (1996)).

5.4.3 Perception-action coupling mechanism

The intrinsic mapping between self and other that was first discovered in the developmental literature is also supported by considerable empirical literature in cognitive psychology. For example, common coding theories claim that somewhere in the chain of operation that leads from perception to action, the system generates certain derivatives of stimulation and certain antecedents of action that are commensurate in the sense that they share the same system of representational dimensions (e.g. Prinz (2002, 2005)). The core assumption of the common coding theory is that actions are coded in terms of the perceivable effects (i.e. the distal perceptual events) they should generate. Performing a movement leaves behind a bidirectional association between the motor pattern it was generated by and the sensory effects that it produces. Such an association can then be used backwards to retrieve a movement by anticipating its effects (Hommel, Müsseler, Aschersleben, & Prinz (2001)).

Perception/action codes are also accessible during action observation, and perception activates action representations to the degree that the perceived and the represented actions are similar, as we saw in the case of infant imitation. Such a mechanism has also been proposed to account for emotion sharing and its contribution to the experience of empathy (Preston & de Waal (2002)). In the context of emotion processing, it is posited that perception of emotion activates in the observer the neural mechanisms that are responsible for the generation of similar emotion. It should be noted that a similar mechanism was previously proposed to account for emotion contagion. Indeed, Hatfield, Cacioppo & Rapson (1994) argued that people catch the emotions of others as a result of afferent feedback generated by elementary motor mimicry of others' expressive behavior, which produces a simultaneous matching emotional experience (see also, Meltzoff & Moore (1995)).

The motor imitation involved in emotion contagion is supported by research using measures of facial electromyography (EMG). In one study, participants were exposed very briefly (56 ms) to pictures of happy or angry facial expressions while EMG was recoded from their facial muscles (Sonnby-Borgstrom, Jonson, & Svenson (2003)).

Results demonstrate facial mimicry despite the fact that the participants were unaware of the stimuli. Furthermore, this effect was stronger for the participants who scored higher on self-reports of empathy.

Another study by Niedenthal, Brauer, Halberstadt, & Innes-Ker (2001) indicates that facial mimicry plays an imperative role in the processing of emotional expression. Participants watched one facial expression morph into another, and were asked to detect when the expression changed. Some participants were free to mimic the expressions, whereas others were prevented from imitating by holding a pencil laterally between their lips and teeth. Participants that were free to mimic detected the changes in emotional expression earlier and more efficiently for any facial expression than did participants who were prevented from imitating the expressions.

In neuroscience, some related evidence for perception/action coupling comes from electrophysiological recordings in monkeys. Neurons with sensorimotor properties, known as mirror neurons, were identified in the ventral premotor and posterior parietal cortices. These mirror neurons fire both during goal-directed actions and observation of the same actions performed by another individual. Most mirror neurons show a clear congruence between the visual actions they respond to and the motor response they code (Rizzolatti, Fogassi, & Gallese (2001)). These neurons are part of a circuit that reciprocally connect the posterior superior temporal gyrus (in which neurons respond to the sight of actions made by others), the posterior parietal cortex, and the ventral premotor cortex.

A mirror neuron system also seems to exist in humans. Numerous functional neuroimaging experiments indicate that the neural circuits involved in action representation (in the posterior parietal and premotor cortices) overlap with those activated when actions are observed (see Jackson & Decety (2004) for a review). In addition, a number of neuroimaging studies have also shown that a similar neural network is reliably activated during imagining of one's own action, imagining another's action, and imitating actions performed by a model (Decety & Grèzes (2006)). Notably, an fMRI study found similar areas engaged when individuals observe or imitate emotional facial expressions. Within this network, there was greater activity during imitation, compared with observation of emotions, in premotor areas including the inferior frontal cortex, as well as in the superior temporal cortex, insula, and amygdala (Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi (2003)). Such shared circuits reflect an automatic transformation of other people's behavior (actions or emotions) into the neural representation of one's own behavior, and provides a functional bridge between first- and third-person perspectives, culminating in empathic experience (Decety & Sommerville (2003); Meltzoff (2007a)).

Recently, a growing number of functional neuroimaging studies have demonstrated striking similarities in the neural circuits involved in the processing of both the first-hand experience of pain and the second-hand experience of observing other individuals in pain (see Jackson, Rainville, & Decety (2006) for a review). For instance, Decety, Michalska and Akitsuki (2008) scanned typically developing children (range

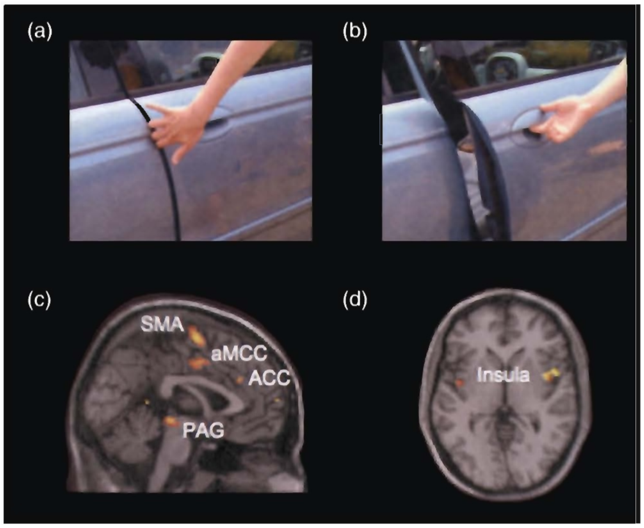

Figure 5.4 When children attend to other people accidentally in pain (A) versus no pain (B), the neuro-hemodynamic signal increases in neural regions that belong to the pain matrix, including the anterior midcingulate cortex (aMCC), anterior cingulate cortex (ACC) supplementary motor area (SMA), periaqueductal gray (PAG) (C) and middle insula (D). The somatosensory cortex was also bilaterally activated, result not shown.

Source: Adapted from Decety, Michalska, & Akitsuki (2008), with permission.

7–12 years) while presented with short animated visual stimuli depicting painful and non-painful bodily situations. The perception of other people in pain in children was associated with increased hemodynamic activity in the neural circuits involved in the processing of first-hand experience of pain, including the insula, somatosensory cortex, anterior midcingulate cortex, periaqueductal gray, and supplementary motor area (see Figure 5.4). This basic somatic sensorimotor resonance plays a critical role in the primitive building block of empathy and moral reasoning that relies on the sharing of other's distress.

5.4.4 *Evidence that social deficits can be tied to poor perception-action coupling*

An effective means to measure the role of perception-action coupling in emotion sharing is via EMG recording of the activation of specific facial muscles in response to viewing other people's facial expressions. Facial mimicry has been defined narrowly as the congruent facial reactions to the emotional facial displays of others, and is thus an expressive component (Hess & Blairy (2001)). Emotion contagion is an affective state that matches the other's emotional display. Thus, facial mimicry can be conceived of as a physical manifestation of emotion contagion, and it occurs at an automatic level in response to viewing others' emotions (Bush, Barr, McHugo, & Lanzetta (1989)).

Individuals with ASD are often reported to lack automatic mimicry of facial expressions. A recent study measured adolescent and adult ASD individuals and controls' automatic and voluntary mimicry of emotional facial expressions via electromyography (EMG) recordings of the cheek and brow muscle regions while participants viewed still photographs of happy, angry, and neutral facial expressions (McIntosh, Reichmann-Decker, Winkelman, & Wilbarger (2006)). The cheek and brow muscles of individuals with ASD failed to activate in response to the videos, indicating that they did not automatically mimic the facial expressions, while the muscles of the normally developing controls showed activation. In attempt to examine a potential link between neural dysfunction and developmental delay of social cognitive skills, one fMRI study found a lack of activation in the inferior frontal gyrus (a key part of the mirror neuron system) in children with ASD as compared to controls during the observation and imitation of basic facial emotion expression (Dapretto et al. (2006)). Difficulties in mimicking other people's emotional expression may prevent individuals with ASD from the afferent feedback that informs them of what others are feeling (Rogers (1999)).

The shared neural representations account in neuroscience, coupled with Meltzoff's (2007a) 'Like-Me' developmental theory, both converge in suggesting that problems with one's perceptual-motor coding or body-schema system may undermine capacities for understanding others. Consequently, it is possible that developmental problems involving sensory-motor processes may have an effect on the capabilities that are crucial for 'primary intersubjectivity,' or the ability to react contingently to others' emotional expressions (Meltzof (2007a); Trevarthen & Aitken (2001)) and therefore the child's ability to resonate emotionally with others. It thus seems plausible that the defects in social and sensory-motor problems in individuals ASD may in part reflect a disturbed motor representation matching system at the neuronal level. This speculation not only helps account for problems in primary intersubjectivity, but also the other sensory-motor symptoms of autism: oversensitivity to stimuli, repetitious and odd movements, and possibly, echolalia.

5.5 Self–Other Awareness and Agency: Mediating Whose Emotions Belong to Whom

The fact that the observation of an emotion elicits the activation of analogous motor representation in the observer, raises the question why there is not complete overlap between internally generated and externally engendered motor representations. It has been speculated that practice with intentional imitation may help infants explore who performs a given action and who is observing, and accordingly, who is the entertainer of a given subjective state and who is an observer (Meltzoff & Moore (1995)). In this way, childhood imitation may bring to conscious awareness what has been termed a sense of 'agency.' Research in the neuroscience and developmental science use the term agency to describe the ability to recognize oneself as the agent of an action, thought, or desire, which is crucial for attributing a behavior to its proper agent (Decety & Chaminade (2003)). Children who are intentionally imitated notice that their actions are being replicated by the other. Through this process, children grasp a sense that the 'other' is an intentional, goal-directed agent like the self, but whose actions are dissociable from one's own, though easily replicated (Meltzoff (2007a)).

This agentive capacity is critical for empathy: in a complete empathic experience, affective sharing must be modulated and monitored by the sense of whose feelings belong to whom (Decety & Jackson (2004)). Further, self-awareness generally and agency in particular are crucial aspects in promoting a selfless regard for the other rather than a selfish desire to escape aversive arousal (Batson, Sager, Garst, Kang, Rubchinsky, & Dawson (1997)).

In sum, the studies reviewed indicate that in addition to perception-action coupling and emotional responsivity being basic building blocks in infancy, a sense of self, agency, and self-other distinctions emerge early in the preverbal period (see also Rochat & Striano (2000)). If infants or adults were restricted only to perceiving others as 'like me,' and nothing more (and we have argued that infants and young children do more than this, see Meltzoff & Moore (1995)), this could potentially be detrimental for the altruistic function of empathy—self–other merging causes personal distress, not pro-social helping behavior (e.g. Decety & Lamm (2009); Lamm, Batson, & Decety (2007)). A sense of agency, however, helps children discriminate self-produced actions from other-produced actions. Importantly, the development of agency in children is bolstered by the emergence of intentional imitation.

5.5.1 Cognitive neuroscience of self–other awareness and agency

One role that cognitive neuroscience can contribute to the study of the self and other is to help conceptually define the distinct dimensions, aspects, and characteristics of the self and other to help address the potential separability or relatedness of each component part of self-processing. It has been proposed that non-overlapping parts of the neural circuit mediating shared representations (i.e. the areas that are activated for self-processing and not for other-processing) generate a specific signal for each form of representation (Jeannerod (1999)). This set of signals involved in the comparison between self-generated actions and actions observed from others ultimately allow the attribution of agency. It has also been suggested that the dynamics of neural activation with the shared cortical network is an important aspect in distinguishing one's own actions from the actions of others (Decety & Jackson (2004); Decety & Grèzes (2006); Jackson, Meltzoff, & Decety (2006)). Furthermore, the fact that the onset of the hemodynamic signal is earlier for the self than for others in a variety of tests (e.g. Jackson, Brunet, Meltzoff, & Decety (2006)) can be considered as a neural signature of the privileged and readily accessible self-perspective.

Accumulating evidence from neuroimaging studies in both healthy individuals and psychiatric populations, as well as lesion studies in neurological patients, indicates that the right inferior parietal cortex, at the junction with the posterior temporal cortex (also called the temporoparietal junction TPJ), plays a critical role in the distinction between self-produced actions and actions generated by others (e.g. Decety, Chaminade, Grèzes, & Meltzoff (2002); Jackson & Decety (2004)). The TPJ is a hetero-modal association cortex, which integrates input from the lateral and posterior thalamus, as well as visual, auditory, somesthetic, and limbic areas. It has reciprocal connections to the prefrontal cortex and to the temporal lobes. Because of these anatomical characteristics, this region is a key neural locus for self-processing that is involved in multi-sensory body-related information processing, as well as in the processing of phenomenological and cognitive aspects of the self (Blanke & Arzy (2005)). Its lesion can produce a variety of disorders associated with body knowledge and self-awareness such as anosognosia, asomatognosia, or somatoparaphrenia. For instance, Blanke, Ortigue, Landis, & Seeck (2002) demonstrated that out-of-body experiences (i.e. the experience of dissociation of self from body) can be induced by electrical stimulation of the right TPJ.

In addition, a number of functional imaging studies point out the involvement of the right inferior parietal lobule in the process of agency. Attribution of action to another agent has been associated with specific increased activity in the right inferior parietal lobe. In one fMRI study, Farrer & Frith (2002) instructed participants to use a joystick to drive a circle along a T-shaped path. They were told that the circle would be driven either by themselves or by the experimenter. In the former case, subjects were requested to drive the circle, to be aware that they drove the circle, and thus to mentally attribute the action seen on the screen to themselves. In the latter case, they were also requested to perform the task, but they were aware that the experimenter drove the action seen on the screen. The results showed that being aware of causing an action was associated with activation in the anterior insula, whereas being aware of not causing the action and attributing it to another person was associated with activation in the right inferior parietal cortex.

Interestingly, individuals experiencing incorrect agency judgments feel that some outside force is creating their own actions. One neuroimaging study found hyperactivity in the right inferior parietal lobule when patients with schizophrenia experienced alien control during a movement selection task (Spence et al. (1997)). Delusions of control may arise because of a disconnection between frontal brain regions, where actions are initiated, and parietal regions where the current and predicted states of limbs are represented.

Another study used a device that allowed modifying the participant's degree of control of the movements of a virtual hand presented on a screen (Farrer et al. (2003)). Experimental conditions varied to the degree of distortion of the visual feedback provided to the participants about their own movements. Results demonstrated a graded hemodynamic activity of the right inferior parietal lobule that parallels the degree of mismatch between the executed movements and the visual reafference. Strikingly, such a pattern of neural response was not detected in schizophrenic individuals who were scanned under the same procedure (Farrer et al. (2004)). Instead, an aberrant relationship between the subject's degree of control of the movements and the hemodymamic activity was found in the right inferior parietal cortex and no modulation in the insular cortex.

The right inferior parietal cortex is also found to be activated when participants mentally simulated actions from someone else's perspective but not from their own (Ruby & Decety (2001)). Similarly, this region was specifically involved when participants imagined how another person would feel in everyday life situations that elicit social emotions (Ruby & Decety (2004)) or painful experiences (e.g. Jackson et al. (2006); Lamm, Batson, & Decety (2007)) but not when they imagined these situations for themselves. Such findings point to the similarity of the neural mechanisms that account for the correct attribution of actions, emotions, pain, and thoughts to their respective agents when one mentally simulates actions for oneself or for another individual.

Some researchers have suggested that right TPJ selectively subserves the attribution of beliefs to other people (e.g. Saxe & Kanwisher (2003)). However, the fact that the TPJ is necessary for the perception of intentionality does not mean that this region is specific to that function (Stone & Gerrans (2006)). Recently, Decety, & Lamm (2007) conducted a meta-analysis of 70 functional neuroimaging studies that reported right TPJ activation in various cognitive tasks, including theory of mind, empathy, perception of agency, and attention-reorienting. Based on the results of this meta-analysis, and the overlap in activation, the authors proposed that the contribution of the right TPJ to social cognition—as seen in theory of mind or empathy tasks—relies on a low-level computational mechanism involved in attention reorientation and generating, testing, and correcting internal predictions about external sensory events (Decety & Lamm (2007)). This mechanism is necessary for the perception of agency, and precedes meta-cognitive abilities such as reading intentions and theory of mind. Based on evidence from electrophysiological recordings in monkeys as well as psychophysics and functional neuroimaging studies in humans, Corbetta and Shulman (2002) proposed that the right TPJ plays a critical function to direct attention to behaviorally relevant sensory stimuli. Additional support for the function of the TPJ was recently provided by an fMRI study that demonstrated that theory of mind and attention-reorienting tasks are associated with similar activation sites in the TPJ (Mitchell (2008)).

5.6 Empathy Demands Top-Down Regulation of First-Person Perspective

Given the sharedness of the representations of one's own emotional states and others, as well as similarities in brain circuits during first- and third-person perspective-taking, it would seem difficult not to experience emotional distress while viewing another's distressed state—and personal distress does not contribute to the empathic process

(Batson et al. (2003); Decety & Lamm (2009)). Indeed, distress in the self would hinder one's inclination to soothe.

Adopting another's perspective, which is a higher-order cognitive task that relies on executive functions, is integral to human empathy and is linked to the development of moral reasoning (Kohlberg (1976)), altruism (Batson (1991)), and a decreased likelihood of interpersonal aggression (Eisenberg, Spinrad, & Sadovsky (2006)).

Perspective-taking is truly a daunting human feat, and is more difficult than one may assume. Regulating personal self-knowledge poses particular difficulty for both human children and adults. A cognitive neuroscience study demonstrated the primacy of the self-perspective. Jackson, Meltzoff, & Decety (2006) asked participants to adopt either a first-person perspective or third-person perspective while imitating observed actions. Structures related to motor representations recruited greater activation, including the somatosensory cortex, during the first-person perspective compared to the third-person perspective, thus implying the immediacy of the first-person experience over that of the third-person perspective.

5.6.1 Perspective-taking induces empathic concern

Of special interest are findings from social psychology that document the distinction between imagining the other and imagining oneself (Batson, Early, & Salvarini (1997)). These studies show that the former may evoke empathic concern (defined as an other-oriented response congruent with the perceived distress of the person in need), while the latter induces both empathic concern and personal distress (i.e. a self-oriented aversive emotional response such as anxiety or discomfort). This observation may help explain why empathy, or sharing someone else's emotion, need not yield pro-social behavior. If perceiving another person in an emotionally or physically painful circumstance elicits personal distress, then the observer may not fully attend to the other's experience and as a result lack sympathetic behaviors.

The role of perspective-taking in generating empathic concern was originally documented in a study conducted by Stotland (1969). In his experiment, participants viewed an individual whose hand was strapped in a machine that participants were told generated painful heat. One group of subjects were instructed to watch the target person carefully, another group of participants were instructed to imagine the way the target felt, and the third group was instructed to imagine themselves in the target's situation. Physiological (palm sweating and vasoconstriction) and verbal assessments of empathy demonstrated that the deliberate acts of imagination yielded a greater response than passive viewing. Empathy seems to be sensitive to perspective-taking, as demonstrated by a series of studies demonstrating the effectiveness of perspective-taking instructions in inducing empathy (Batson et al. (1997)) and that empathy-inducing conditions do not compromise the distinction between the self and other (Batson, et al. (1997), but see Cialdini, Brown, Lewis, Luce, & Neuberg (1997) for a different account of empathy and self-other merging).

A recent functional MRI study by Lamm, Batson, & Decety (2007) investigated the distinction between empathic concern and personal distress combining a number of behavioral measures and event-related fMRI. Participants were asked to watch a series of video-clips featuring patients undergoing painful medical treatment either with the instruction to put themselves explicitly in the shoes of the patient ('imagine self'), or, in another condition, to focus their attention on the feelings and reactions of the patient ('imagine other'). Behavioral measures confirmed previous social psychology findings that projecting oneself into an aversive situation leads to higher personal distress and lower empathic concern—while focusing on the emotional and behavioral reactions of another's plight is accompanied by higher empathic concern and lower personal distress. Neuroimaging data were consistent with such findings. The self-perspective evoked stronger hemodynamic responses in brain regions involved in coding the motivational-affective dimensions of pain, including bilateral insular cortices and anterior medial cingulate cortex. In addition, the self-perspective led to stronger activation in the amygdala, a limbic structure that plays a critical role in fear-related behaviors, such as the evaluation of actual or potential threats. Interestingly, the amygdala receives nociceptive information from the spino-parabrachial pain system and the insula, and its activity appears closely tied to the context and level of aversiveness of the perceived stimuli. Imagining oneself to be in a painful and potentially dangerous situation thus triggers a stronger fearful and/or aversive response than imagining someone else to be in the same situation. Regarding the insular activation, it is worth noting that it was located in the mid-dorsal section of this area. This part of the insula plays a role in coding the sensory-motor aspects of painful stimulation, and it has strong connections with the basal ganglia, in which activity was also higher when adopting the self-perspective. Taken together, activity in this aspect of the insula possibly reflects the simulation of the sensory aspects of the painful experience. Such a simulation might both lead to the mobilization of motor areas (including the SMA) in order to prepare defensive or withdrawal behaviors, and to interoceptive monitoring associated with autonomic changes evoked by this simulation process.

Previous research on the neural underpinnings of empathy has been limited to affective situations experienced in a similar way by an observer and a target individual. In daily life, however, we also interact with people whose affective states can be very different from our own. In a recent functional MRI study by Lamm, Meltzoff, & Decety (2010), participants were asked to evaluate the feelings of neurological patients who had emotional reactions that were very different from the self. These patients reacted with no pain when receiving a needle injection but with pain to a soft touch by a Q-tip. Empathic understanding for these patients increased activation in areas involved in self–other distinction and cognitive control (right TPJ, dorso-medial prefrontal cortex and right ventral premotor cortex). Furthermore, neural connectivity between the latter and areas implicated in affective coding was enhanced when participants observed surgical procedures that would be painful for themselves, but were not painful for the patients. This suggests that in order to correctly infer the affective state of someone who is not like us, we have to overcome our own emotional response tendencies. These results demonstrate that fronto-cortical attention networks are crucially involved in this process, corroborating that empathy is a flexible phenomenon, which draws upon both automatic and controlled cognitive mechanisms.

5.6.2 Disorders of empathy and deficits in perspective-taking

Children with empathy deficits likewise show deficits in executive function. A series of studies found that when an experimenter feigns distress in a room where children were playing, children with ASD looked to the experimenter much less than typically developing and mentally retarded children (e.g. Corona, Dissanayake, Arbelle, Wellington, & Sigman (1998)). However, when Blair (1999) replicated such studies, but controlled for executive function demands of attention, children with ASD performed like other children: when experimenters' feigned distress was unambiguous and took place under conditions of low distractibility, children with ASD showed autonomic responses similar to controls. In studies measuring facial mimicry, when given ample time, individuals with ASD do show affective compensatory tactics to accomplish emotion reading and in emotion recognition tasks, and show activation in brain areas related to intentional attentional provision and categorization instead of automatic processing (Hall, Szechtman, & Nahmias (2003)). These data indicate that alongside bottom-up information processing deficits (e.g. mimicry), top-down executive control are also impaired in individuals with autism. The deficit in cognitive flexibility may contribute to apathetic behaviors characteristic of autism.

Violent offenders, and children with aggressive behavior problems, experience deficits in empathy, though the result of the lack of empathy manifests in behavior differently than that seen in ASD or developmental coordination disorder. The former responds aggressively to others' distress (Arsenio & Lemerise (2001)), while the latter simply lack pro-social behavior. The distinction can be understood as the difference between apathy and hostility, both of which are categorized as non-empathetic in the traditional sense, though one being 'passive,' and the other 'active.' Individuals with ASD seem to have a deficit in either an interest or capacity to resonate emotionally with others or engage in intersubjective transactions. In contrast, children with developmental aggression disorders react aggressively to the observation of others' distress.

Poor empathic ability in conduct disorder correlates with decreased noradrenergic (NA) function (Raine (1996)). In fact, a low resting heart rate (a partly heritable trait reflecting fearlessness and stimulation-seeking) at 3 years of age predicted aggressive behavior at 11 years of age (Raine, Venables, Mednick, & Sarnoff (1997)). Children with clinical levels of behavior problems, often a precursor to the development of conduct disorder, show increased disregard for others, for example anger, avoidance, and/or amusement by another's distress, a negatively toned response pattern that differs significantly from typical children's responses. It is likely that decreased NA function, which is associated with aggressive behavior, contributes to these anti-social reactions.

Of particular interest are the aggressive and non-empathetic reactions of what have colloquially been termed 'bullies.' This sub-population also falls within the category of anti-social, but their reactions seem to be specific to aggressive responses to peers in distress. Dautenhahn & Woods (2003) proposed a model to account for the empathy deficits observed in bullies. They suggest that bullies as well as psychopaths are not aggressive due to poor emotion-processing or perspective-taking, but instead have heightened goal-directed behavior, often with an aggressive, anti-social goal to inflict personal distress in the other. This model is particularly intriguing as it questions previously held beliefs that males with conduct disorders experience weak self-regulation (Gill & Calkins (2003)). This novel model has particular implications for the role of perspective-taking in empathy. Personal motivation (i.e. the desire to induce distress in the other, versus the desire to offer pro-social help) plays a crucial role—because the bully or psychopath may have the means for an empathic experience, however the goal to elicit distress.

In an initial functional MRI study, eight adolescents with aggressive conduct disorder (CD) and eight matched controls with no CD symptoms were scanned while watching animated visual stimuli depicting other people experiencing pain or not experiencing pain (Decety, Michalska, Akitsuki, & Lahey (2009)). Furthermore, these situations involved either an individual whose pain was caused by accident or an individual whose pain was inflicted on purpose by another person. The aggressive youth activated the neural circuits underpinning pain processing to the same extent, and in some cases, even more so than the control participants without conduct disorder. Aggressive adolescents showed a specific and very strong activation of the amygdala and ventral striatum (an area that responds to feeling rewarded) when watching pain inflicted on others, which suggested that they enjoyed watching pain. When watching situations in which pain was intentionally inflicted, control youths exhibited signal increase in the medial prefrontal cortex, lateral orbitofrontal cortex, and right temporo-parietal junction (regions processing intentions and involved in moral reasoning), whereas youths with CD only exhibited activation in the insula and precentral gyrus. Furthermore, connectivity analyses demonstrated that youths with CD exhibited less amygdala/prefrontal coupling when watching pain inflicted by another than did control youth.

Executive functions not only facilitate perspective-taking, but also control attention and meta-cognitive capacities, both of which facilitate pro-social responding in reaction to another's distress. Children first demonstrate responses to the distress of others with other-focused behaviors like concern, attention to the distress of the other, cognitive exploration of the event and pro-social interventions around the second year of life. At this age children manifest a multifaceted self-concept, self-conscious emotions, as well as reparative behaviors after they cause distress in the other (Zahn-Waxler, Radke-Yarrow, Wagner, & Chapman (1992)). A longitudinal study of young children's development of concern for others' distress showed that pro-social behaviors, such as hugs and pats, emerge around the beginning of the second year of life, increasing in intensity throughout this year and sometimes provide self-comfort. However, by the end of the second year, pro-social behaviors appear to be more appropriate to the victims needs, are not necessarily self-serving, and children's emotions appear to be better regulated (Radke-Yarrow & Zahn-Waxler (1984)).

The ability to regulate emotions may be subject to individual differences, and may interact with the degree to which individuals experience emotions. Eisenberg and her colleagues (1994) proposed a model suggesting an interaction between the intensity at which emotions are experienced and the extent to which individuals can regulate their emotions. In line with her model, multi-method analysis of empathy-related responses including self-reported, facial, and heart rate responses suggest that increased emotional intensity and decreased regulation predict personal distress. Emotion contagion corresponds with moderate emotionality when regulation is controlled, and perspective-taking corresponds with high regulation and high emotionality only when perspective-taking is controlled. These interactions are first seen in a primitive form in infancy, and findings from infant development demonstrate that 4-month-olds low in self-regulation are prone to personal distress at 12-months of age (Ungerer et al. (1990)). In childhood, individuals with increased levels of emotional intensity (based on self-report, teacher-parent report, and autonomic measurements) and weak regulation are prone to personal distress in response to another's predicament, as they become overwhelmed due to their vicariously induced negative emotions.

In summary, the maturation of executive functions allow for the shared representations between self and other to be mediated and pro-social behaviors follow suit. On the other hand, if executive functioning is not intact, self and other perspectives may not be regulated, and individuals may over-identify or under-identify with an observed target. In the case of childhood aggression and conduct disorder, it is likely that either over- or under-regulation contributes to empathy deficits, though other factors such as NA function, or the environmental context and past experiences also contribute to reactionary behaviors.

5.7 Conclusion

We have shown that empathy is a complex and interesting human capacity that has both developmental origins and neural correlates. We argued that imitation and empathy are linked. It seems likely that basic motor imitation and complex imitation of intentional acts support empathy development and social understanding in general. The supramodal representation of human action that underlies infant motor imitation (Meltzoff & Moore (1997)) helps explain how perception and action can be so closely coupled and provides a basis for the interpersonal bridge that exists between self and other from the early pre-verbal stages of psychological development. This review also addressed the equivalent deficits in imitation and empathy in certain developmental disorders, particularly ASD, anxiety-depression, and conduct disorders. At an applications level, imitation may serve as an excellent remediation technique for enhancing empathy in these populations.

In our view, empathy cannot be entirely conceived within an experimental or neuroscientific vacuum. Personality, temperaments, and cultural norms of emotional display also contribute to the degree to which empathy may be experienced in the observer (e.g. Posner & Rothbart (2000)) and also modulated or even inhibited. In development, girls are more prone to comprehend emotional display rules than boys, particularly in cultures in which feminine roles demand more management and control of emotion display. Likewise, children from cultures that promote reciprocal relations and cooperation tend to be better at perspective-taking tasks than children living in individualistic cultures (Eisenberg, Bridget, & Shepard (1997)). Social psychologists emphasize the role of situational context as opposed to personality in the experience of empathy (or the absence of it), although most recognize a complex interaction between situation and personality as the best predictor of social behavior (Fiske (2004)). While situational context is important, creating ecologically valid situations in a laboratory setting poses a challenge (Decety & Batson (2007)). Thus, designing ecologically valid experiments for interpersonal exchanges involving empathy remains a challenging process, especially with children.

A current trend in cognitive neuroscience is to study the interaction between affect and cognition. Empathy and imitation exemplify this complex process: Motor imitation is foundational to emotion sharing, which is the building block of empathy which in turn affects the projected mental state content during perspective-taking (with feedback/forward loops). Moreover, affective and social cognitive developmental neuroscience offers promising insights into both our understanding of typical and psychopathological social behavior.[1]

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